

# Distinct Element Modeling of the Drift Scale Test

*S. C. Blair, S. R. Carlson, J. L. Wagoner*

This article was submitted to  
American Rock Mechanics Association, DC Rocks: "Rock Mechanics in  
the National Interest" the 38th U. S. Rock Mechanics Symposium,  
Washington, D.C., July 7-10, 2001

**U.S. Department of Energy**

Lawrence  
Livermore  
National  
Laboratory

**September 29, 2000**

## DISCLAIMER

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

This is a preprint of a paper intended for publication in a journal or proceedings. Since changes may be made before publication, this preprint is made available with the understanding that it will not be cited or reproduced without the permission of the author.

This work was performed under the auspices of the United States Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

This report has been reproduced directly from the best available copy.

Available electronically at <http://www.doc.gov/bridge>

Available for a processing fee to U.S. Department of Energy  
And its contractors in paper from  
U.S. Department of Energy  
Office of Scientific and Technical Information  
P.O. Box 62  
Oak Ridge, TN 37831-0062  
Telephone: (865) 576-8401  
Facsimile: (865) 576-5728  
E-mail: [reports@adonis.osti.gov](mailto:reports@adonis.osti.gov)

Available for the sale to the public from  
U.S. Department of Commerce  
National Technical Information Service  
5285 Port Royal Road  
Springfield, VA 22161  
Telephone: (800) 553-6847  
Facsimile: (703) 605-6900  
E-mail: [orders@ntis.fedworld.gov](mailto:orders@ntis.fedworld.gov)  
Online ordering: <http://www.ntis.gov/ordering.htm>

OR

Lawrence Livermore National Laboratory  
Technical Information Department's Digital Library  
<http://www.llnl.gov/tid/Library.html>

## **Distinct Element Modeling of the Drift Scale Test**

Stephen C. Blair, Steven R. Carlson, Jeffery L. Wagoner

Lawrence Livermore National Laboratory  
Livermore, California 94550

*Primary Contact: Stephen C. Blair, L-201, Lawrence Livermore National Laboratory, P.O. Box 808, Livermore CA, 94551, Ph 925-422-6467, Fax 925-423-1057, email: blair5@llnl.gov.*

A drift-scale distinct element model (DSDE) is being used to analyze geomechanical behavior in the Drift Scale Test (DST) now underway at Yucca Mountain, Nevada. The DST is a large-scale, long-term thermal test designed to investigate coupled thermal-mechanical-hydrological-chemical behavior in a fractured, welded tuff rock mass. Electric heaters are being used to heat a 50 m length of drift for 4 years, followed by 4 years of cooling. The target drift wall temperature is 200°C during much of the heating period. The distinct element method was chosen to permit explicit modeling of fracture deformations. Shear deformations and normal mode opening of fractures are expected to increase fracture permeability and thereby alter thermal-hydrologic behavior in the DST region.

This paper will describe the DSDE model and present preliminary modeling results, including temperature and stress fields, and normal and shear fracture displacements at a series of times after start of heating. Figure 1 shows the drift geometry and associated fracture planes used in the simulations. The fracture locations and orientations were determined by analysis of borehole video logs.

Predicted normal mode fracture deformations are concentrated along and above the heated drift (Figure 2). The results indicate similar magnitudes and spatial distributions of normal deformations at all four times. Some normal mode opening is indicated after 4 years of heating on two subvertical fractures that extend to the edge of the modeled region. This fracture opening is not shown after 8 years, indicating that normal mode opening may be reversible.

Predicted shear fracture deformations shown in Figure 3 are also concentrated above the heated drift, but are generally larger, and the predictions for 4 and 8 years is very similar, indicating that the shear deformation may not be recoverable upon cooling. The predicted fracture deformations are consistent with observed microseismic and acoustic emission activity, which indicate that rock movement is occurring along a few vertical fractures above the heated drift.

### **a) Drift Geometry for DST**

↖ **Heated Drift**

### **b) Fractures in Simulated Block**

Figure 1. Drift geometry and associated fracture planes for DST simulation. (a) drift geometry for Drift Scale Test. (b) Fracture geometry within simulated block. Note that the drifts shown in (a) are contained within the rockmass shown in (b).

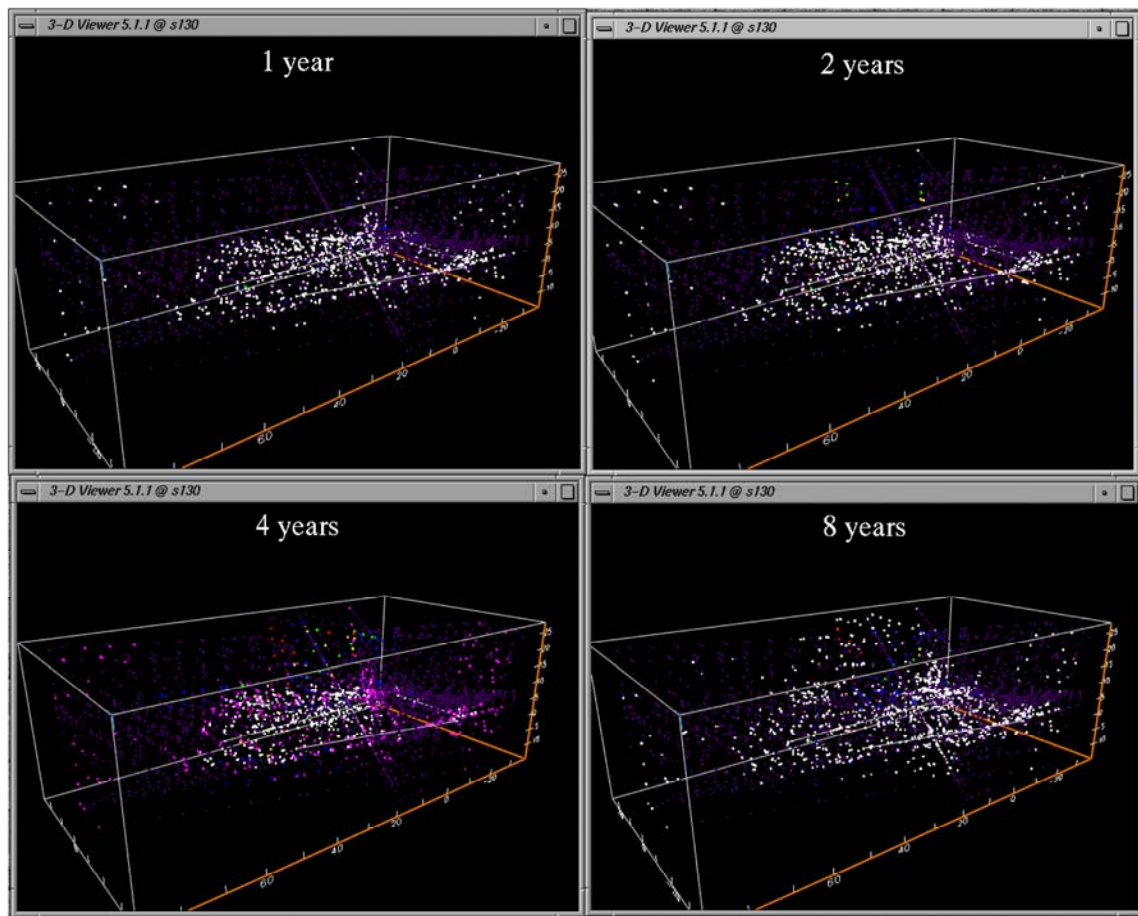


Figure 2. Perspective view of the DST region showing predicted normal mode fracture displacements (colored dots) after 1, 2 and 4 years of heating, and at 8 years, following four years of cooling. Legend is given in Table 1. Faint white lines indicate centerlines of drifts.

Color	Fracture Deformation (mm)
White	< -0.5 (normal closing)
Light Purple	-0.05 - 0.0 (normal closing)
Dark Purple	0.0 - 0.1
Blue	0.1 - 0.5
Green	0.5 - 1
Yellow	1 - 2
Red	>2

Table 1. Legend for fracture displacement plots. Negative values pertain only to normal mode deformations.

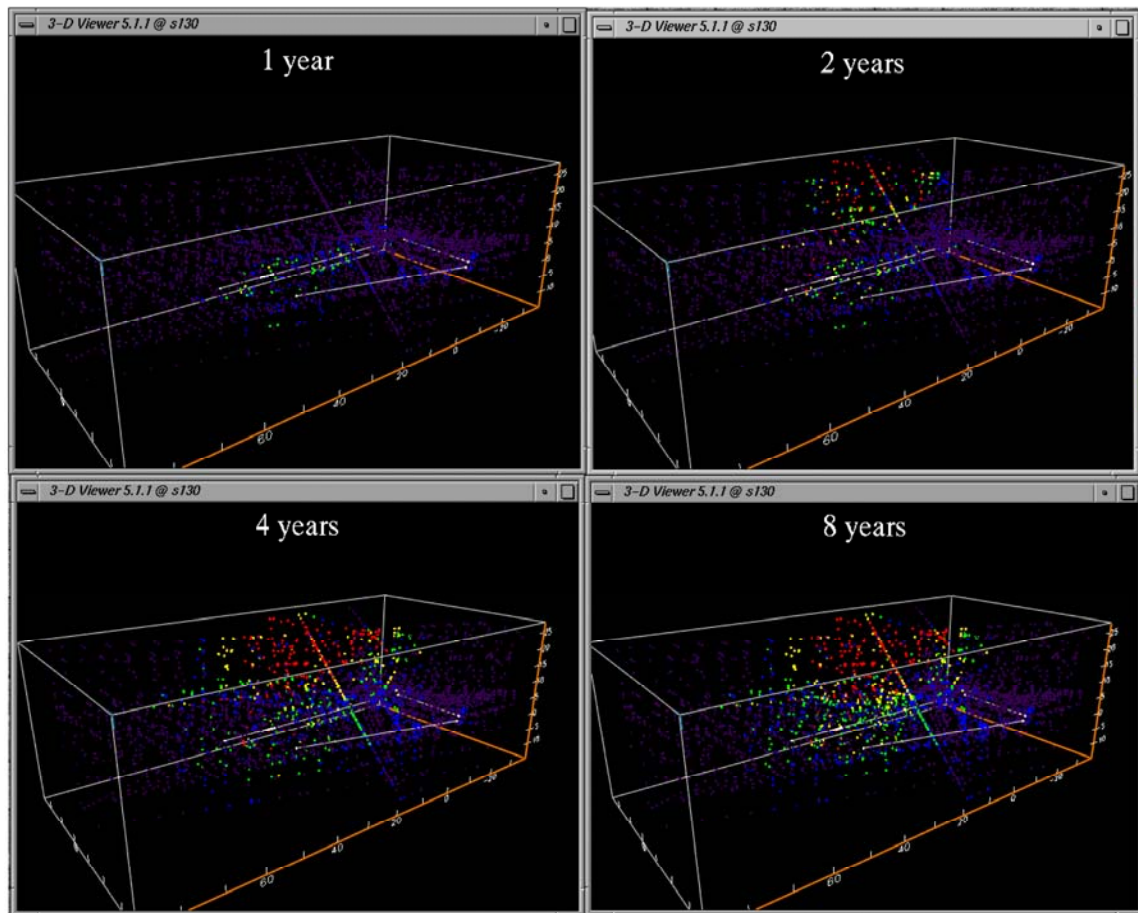


Figure 3. Perspective view of the DST region showing predicted shear fracture displacements (colored dots) at the same times as Figure 2. Legend is given in Table 1. Faint white lines indicate centerlines of drifts.